Term Information

Effective Term	Autumn 2023

General Information

Course Bulletin Listing/Subject Area	Mathematics
Fiscal Unit/Academic Org	Mathematics - D0671
College/Academic Group	Arts and Sciences
Level/Career	Undergraduate
Course Number/Catalog	4345
Course Title	Formal Proof
Transcript Abbreviation	Formal Proof
Course Description	This course provides an introduction to formal proof in mathematics. It is designed for math majors who seek a comprehensive under- standing of how to use proof assistants and how to encode a mathematical proof in such a way that one can formally verify its correctness.
Semester Credit Hours/Units	Fixed: 3

Offering Information

Length Of Course	14 Week, 12 Week, 8 Week, 7 Week, 6 Week
Flexibly Scheduled Course	Never
Does any section of this course have a distance education component?	No
Grading Basis	Letter Grade
Repeatable	No
Course Components	Lecture
Grade Roster Component	Lecture
Credit Available by Exam	No
Admission Condition Course	No
Off Campus	Never
Campus of Offering	Columbus

Prerequisites and Exclusions

Prerequisites/Corequisites	A grade of C- or better in 3345 or permission of department.
Exclusions	
Electronically Enforced	Yes

Cross-Listings

Cross-Listings	

Subject/CIP Code

Subject/CIP Code	27.0101
Subsidy Level	Baccalaureate Course
Intended Rank	Junior, Senior

Requirement/Elective Designation

The course is an elective (for this or other units) or is a service course for other units

Course Details

Course goals or learning objectives/outcomes

- The student will be able to use a proof assistant to write formal proofs of basic mathematical theorems, using a variety of techniques such as induction, contradiction, case analysis;
- The student will be able to read and understand existing formal proofs and identify techniques used;
- The student will be able to write clear and concise mathematical prose commenting on formal proofs;
- The student will collaborate effectively with other students in writing and reviewing formal proofs, and provide constructive feedback on their peer's work;
- The student will be able to explain the correspondence between proofs and programs;
- The student will be able to make use of a library of previously proved results (like mathlib) to make progress on problems in various areas of mathematics such as algebra, analysis, geometry, and combinatorics;
- The student will understand fundamental concepts of dependent type theory such as introduction and elimination rules, and relate those rules to the writing of formal proofs.

Content Topic List

- Natural numbers and induction; Order and divisibility
- Logic and propositions; Proof terms and tactics
- Examples: inequalities and sequences
- Functions
- Set theory
- Equivalence relations and quotients
- Induction and recursion
- Examples: number theory, point-set topology, metric spaces, abstract algebra

Sought Concurrence

No

Attachments

- 4345syllabus.pdf: Syllabus

  (Syllabus. Owner: Husen,William J)

- Curriculum_map_math_03272023.docx: Curriculum map

  (Other Supporting Documentation. Owner: Husen,William J)

Comments

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Husen,William J	03/27/2023 01:15 PM	Submitted for Approval
Approved	Husen,William J	03/27/2023 01:23 PM	Unit Approval
Approved	Vankeerbergen,Bernadette Chantal	04/05/2023 12:55 PM	College Approval
Pending Approval	Jenkins,Mary Ellen Bigler Hanlin,Deborah Kay Hilty,Michael Vankeerbergen,Bernadette Chantal Steele,Rachel Lea	04/05/2023 12:55 PM	ASCCAO Approval

Math 4345 Formal Proof: Sample Syllabus

March 6, 2023

Course Title: Formal Proof
Credit Hours: 3

Textbook: *Mathematics in Lean* by Jeremy Avigad, Kevin Buzzard, Robert Lewis, Patrick Massot.
This textbook is driven by examples, and similarly this course will involve examples drawn from across the mathematical landscape.
Prerequisites/Corequisites:: A grade of $C-$ or above in Math 3345.

Description. This course provides an introduction to formal proof in mathematics. It is designed for math majors who seek a comprehensive understanding of how to use proof assistants and how to encode a mathematical proof in such a way that one can formally verify its correctness. Throughout the course, students will engage in weekly homework assignments, a midterm project, and a final project. By the end of this course, students will be able to take their prior mathematical learning and communicate it in a format suitable for machine verification.

Course goals or learning objectives/outcomes. By the end of the course,

- the student will be able to use a proof assistant to write formal proofs of basic mathematical theorems, using a variety of techniques such as induction, contradiction, case analysis;
- the student will be able to read and understand existing formal proofs and identify techniques used;

- the student will be able to write clear and concise mathematical prose commenting on formal proofs;
- the student will collaborate effectively with other students in writing and reviewing formal proofs, and provide constructive feedback on their peer's work;
- the student will be able to explain the correspondence between proofs and programs;
- the student will be able to make use of a library of previously proved results (like `mathlib`) to make progress on problems in various areas of mathematics such as algebra, analysis, geometry, and combinatorics;
- the student will understand fundamental concepts of dependent type theory such as introduction and elimination rules, and relate those rules to the writing of formal proofs.

Planned curriculum

Course content is drawn from the *Mathematics in Lean* textbook, with weekly worksheets reinforcing the content from the textbook. About half the course is "examples" meaning that some basic definitions from a given area of mathematics are formalized and students are challenged to prove fundamental results.

1. Natural numbers and induction
2. Order and divisibility
3. Logic and propositions
4. Proof terms and tactics
5. Examples: inequalities
6. Examples: sequences
7. Functions
8. Set theory

9. Equivalence relations and quotients
10. Induction and recursion
11. Examples: number theory
12. Examples: point-set topology
13. Examples: metric spaces
14. Examples: abstract algebra

Assessment

There are 500 points possible in this course; earning an A or B or C or D requires earning 450 or 400 or 350 or 300 points, respectively. These points are broken down as follows.

Homework (260 points; 20 points each). There will be thirteen homework assignments posted on the course website. You will receive a portion of 20 points for each of these assignments based on your performance. Your work should be well-organized and should provide well-commented code and clear written arguments where appropriate. **Your submitted homework must list those with whom you have collaborated.**

Midterm and final project (240 points; 120 points each). Each project involves writing up a formal proof for a result you have learned in a previous math course. Projects must include both code and a write-up (of a few pages) explaining the approach you have taken. Students will be graded on the correctness of their code and quality of their exposition.

Academic integrity policy

Your written assignments must be your own work, but you should discuss problems with other students in this course and seek out additional resources and readings. The write-up must be entirely your own. **Your submitted homework must list those with whom you have collaborated.** If you are unsure about a particular situation, please ask the instructor.

Academic Misconduct Statement

It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335–5–48.7). For additional information, see the Code of Student Conduct at `http://studentlife.osu.edu/csc/`

Statement on title IX

Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories (e.g., race). If you or someone you know has been sexually harassed or assaulted, you may find the appropriate resources at `http://titleix.osu.edu` or by contacting the Ohio State Title IX Coordinator, Kellie Brennan, at `titleix@osu.edu`.

Disability Services Statement

The University strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability (including mental health, chronic or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. SLDS contact information: `slds@osu.edu`; 614-

292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

Religous accomodations

Our inclusive environment allows for religious expression. Students requesting accommodations based on faith, religious or a spiritual belief system in regard to examinations, other academic requirements or absences, are required to provide the instructor with written notice of specific dates for which the student requests alternative accommodations at the earliest possible date. For more information about religious accommodations at Ohio State, visit odi.osu.edu/religious-accommodations.

Your mental health

As a student you may experience a range of issues that can cause barriers to learning such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know are suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental health services available on campus via the Office of Student Life's Counseling and Consultation Service (CS) by visiting ccs.osu.edu or calling 614-292-5766. CCS is located on the 4th Floor of the Younkin Success Center and 10th Floor of Lincoln Tower. You can reach an on call counselor when CCS is closed at 614-292-5766 and 24 hour emergency help is also available through the 24/7 National Suicide Prevention Hotline at 1-800-273-TALK or at suicidepreventionlifeline.org